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1 562 688

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(19)

(54) IMPROVEMENTS RELATING TO LIGHTWEIGHT BUILDINGS

(71) We, WARD BROTHERS (SHERBURN) LIMITED, a British company of Widespan Works, Sherburn, Malton, Yorkshire, YO17 8PQ, do hereby declare the invention for which we pray that a patent may be granted to us and the method by which it is to be performed to be particularly described in and by the following statement:

This invention relates to lightweight buildings.

It is an object of the invention to provide a new and improved lightweight building which is particularly suitable for transport in knocked-down condition and erection on site without the need for sophisticated techniques such as welding.

According to the present invention we provide a lightweight building including a pitched roof comprising a plurality of pairs of rafters, the rafters of each pair being connected together at one end, co-planar and mutually inclined, the pairs of rafters being arranged in side by side relationship with purlins extending between adjacent pairs wherein each rafter comprises at least one cold rolled section comprising a pair of spaced parallel flange portions and a web extending between said flange portions the web comprising a planar central part which extends normal to the flange portions and is flanked by at least one inclined part so that the plane of the central part intersects at least one flange portion.

The other ends of each rafter may be interconnected by a tension element.

Each rafter may comprise a single cold rolled section.

Each rafter may comprise a lattice girder comprising cold rolled upper and lower booms interconnected by lattice elements.

The upper and lower booms may each comprise a pair of spaced parallel flange portions and a web extending between said flange portions and there being lattice elements extending between adjacent flanges of the upper and lower booms.

The lattice elements may comprise tubes preferably of circular cross section, with flattened end portions.

The upper and lower booms and lattice elements may be connected together by fastener elements, and preferably are removably connected together, for example, by means of screw threaded fasteners.

The lattice girder may have, about a first axis a moment of inertia lying in the range 14,352 - 68,667 cm^4; a section modulus lying in the range 638 - 1308 cm^3; a radius of gyration lying in the range 40 - 50 cm; and, about a second axis, a moment inertia lying in the range 186 - 2532 cm^4; a section modulus lying in the range 32 - 200 cm^3; a radius of gyration lying in the range 4.5 - 10cm; and having a weight per metre lying in the range 10 - 30 kg.

A rafter may be supported at its said other end by a stanchion comprising a cold rolled section.

Each stanchion may comprise a pair of spaced interconnected stanchion elements, one element being connected to a rafter at or adjacent said other end of the rafter and the other stanchion element being connected to the rafter at a position spaced inwardly of the positions of connection of the first stanchion element.

Preferably the stanchion elements converge downwardly and are mounted on a common foundation engaging base.

Preferably said one stanchion element is vertical and the other stanchion element is co-planar therewith and inclined thereto.

Alternatively, a rafter may be supported at said other end by a stanchion comprising a hot rolled section and the section may be an I-section.

A stanchion may be provided at said one end of each rafter and the stanchions may be inter-connected by a cold rolled eaves rail at or adjacent their upper ends and by cold rolled side rails and the cladding may be supported on cold rolled purlins of the roof and the eaves rail and the side rails of the stanchions.

The rafters, stanchions, purlins, eaves rail, and side rails may be releasably connected together by fasteners thereto.

The or each flange portion of the cold rolled section may be of generally L-shape in cross-section, one leg of the L being shorter than the other and constituting a lip on said one flange portion.

The lip may extend outwardly on the opposite side of the flange portion to the central part or may extend inwardly on the same side of the flange portion to the central part and may extend normal to its flange part or be inclined thereto in the direction towards or away from the central part.

The inclined part of the cold rolled section may extend on the opposite side of the central part at the end of the flange.

The central part of the cold rolled section may be flanked by two inclined parts and said inclined parts may extend on the same side as the central part and diverge away from each other or may extend on opposite sides of the central part and lie generally parallel.

The inclined part may extend directly to the flange portion or may be connected to their associated flange portion by an end part which lies parallel to said central part.

At least one of the cold rolled sections may have, about a first asix, a moment of inertia lying in the range 93 - 1266 cm^4; a section modulus lying in the range 16 - 100 cm^3; a radius of gyration lying in the range 4.5 - 9.7 cm and, about a second axis, a moment of inertia lying in the range 24 - 47 cm^4; a first section modulus lying in the range 5.6 - 10.5 cm^3; a second section modulus lying in the range 7.9 - 15.3 cm^3; a radius of gyration lying in the range 2.3 - 1.8 cm and a weight per metre lying in the range 3.5 - 10.8 kg.

Three embodiments of the invention will now be described in more detail by way of example with reference to the accompanying drawings wherein:

Figure 1 is a perspective view of one embodiment of a building embodying the invention,

Figure 2 is an end elevation of the building of Figure 1,

Figure 3 is a fragmentary perspective view showing the connection between a stanchion element rafter and eaves beams of the building of Figure 1,

Figure 4 is a cross sectional view through a stanchion of the building of Figure 1,

Figure 5 is an end elevation of the other end of the building of Figure 1 prior to fitment of the purlins side rails and cladding and illustrating the end of the building,

Figure 6 is an end elevation of another embodiment of the invention,

Figure 7 is a fragmentary persepective view illustrating the connection between a rafter and side wall of the building of Figure 6,

Figure 8 is a diagrammatic plan view illustrating a modification of the building of Figure 1,

Figure 9 is an exploded perspective view of another embodiment of a building embodying the invention,

Figure 10 is a fragmentary exploded perspective view showing the connection between a stanchion element and a rafter of the building of Figure 9,

Figure 11 is a fragmentary perspective view showing the connection between two rafters at the apex of the building of Figure 1,

Figure 12 is a side elevation of a rafter of the building of Figure 1, and

Figures 13 to *18* illustrate various cross-sectional shapes.

Referring now to Figures 1 to 5 there is illustrated a building comprising a pitched roof 10 including a framework 11 which is clad with metal sheets 12.

The framework 11 comprises a plurality of pairs of rafters 13. The rafters of each pair are co-planar and are connected together at their one ends 14 and a tension member in the form of a galvanised tie-rod 15 extends between and connects together the other ends 16. As shown in Figure 1 the rod 15 does not extend completely to the ends 16 but is connected to the rafters at a position spaced somewhat inwardly of the ends 16.

Each rafter 11 comprises a section of the shape shown in Figure 13 and comprises a pair of spaced parallel flange portions 17 interconnected by a web 18 having a planar central part 19 flanked by two diverging parts 20 such that the plane of the central part 19 intersects the flange portions 17. The flange portions 17 are of L-shape in cross section one leg 21 of the L-section being shorter than the other and constituting an inturned lip on said one flange portion. The sections are made by cold rolled forming from sheet steel. The sections may be of other cross-section instead of that shown in Figure 13 for example the sections shown in Figures 14 to 18.

The section shown in Figure 13 has the parameters set out in Column A below and may have parameters lying within the ranges set out in column B.

		A	B
	1 XX	260.1 cm^4	93 1266 cm^4
	Z X	31.5 cm^3	16 - 100 cm^3
5	R XX	6.6 cm	4.5 - 9.7 cm^3
	I YY	28.2 cm^4	24 - 47 cm^4
	Z Y1	6.5 cm^3	5.6 - 10.5 cm^3
	Z Y2	9.5 cm^3	7.9 - 15.3 cm^3
	R YY	2.1 cm	2.3 - 1.8 cm
10	Wt/m	4.8 Kg	3.5 - 10.8 Kg

Each pair of rafters 13 are joined together by purlins 22 which are also made by cold rolled forming of sheet metal and again preferably of the configuration shown in Figure 13 or may be of the configuration shown in Figures 14 to 18. The purlins 22 are connected to the rafters 13 by bolting together the lower flange 17 of the purlin and the upper flange 17 of the rafter.

The metal sheets 12 are secured to the purlins in conventional manner.

A support link 23 is provided between the centre of the tension element 15 and the apex of each pair of rafters 13 to prevent sagging of the tension element 15.

In the embodiment described with reference to Figures 1 to 5 the pitched roof thus described is supported by stanchions 24. A stanchion 24 is provided to support the one end of each rafter 13.

Each stanchion 24 comprises a pair of cold rolled stanchion elements 25 each of which is preferably of the configuration shown in Figure 13 but may be of the configuration shown in Figures 14 to 18. The stanchion elements 25 are connected together by members 26 and, at their lower ends, are connected to angle members 27 bolted to a concrete foundation 28 as best shown in Figure 4.

One of the stanchion elements 25 is vertical and is connected to the one end of the rafter 13 by means of angle brackets bolted to the external surfaces of the upper and lower flanges 17 of the girder and the central part 19 of the web of the stanchion element 25.

This one stanchion element 25 also has connected thereto by means of a bracket 29 eaves beams 30 again formed of cold rolled sheet of material and preferably of the configuration shown in Figure 13 but may be of the configuration shown in Figures 14 to 18.

The other stanchion element 25 is co-planar with said one stanchion element but is inclined thereto so as to converge downwardly and inwardly relative to said one stanchion element from a position of attachment to the rafter 13 at a position spaced inwardly of the position of attachment of said one stanchion element.

If desired, as shown on the left hand side of Figure 2, the one stanchion element 25 may be connected to the rafter 13 at a position adjacent to said other end 16 but spaced inwardly thereof. In this case the rafter 13 would be connected to one said of the stanchion element 25.

Extending between the stanchion elements are provided side rails 31 again formed of cold rolled sheet metal and preferably of the shape shown in Figure 13 but which may be of the shapes shown in Figures 14 to 18. Metal side cladding is secured to the eaves rail 30 and side rails 31.

As shown in Figure 5 if desired and if the size of the buildings requires it, gable posts 33 may be provided at one or each end of the building together with horizontal gable rails 34.

If the length of the building is such that there are more than 10 bays between adjacent pairs of rafters 13 appropriate cross bracing is provided between the rafters 13 and the stanchions 24, as shown in Figure 8, to ensure that the building is rigid.

In an alternative embodiment described with reference to Figures 6 and 7 the building comprises a pitched roof of the same construction as described with reference to Figures 1 to 5 and the same reference numerals have been used in Figures 6 and 7 to refer to corresponding parts. However instead of the roof being supported on stanchions 24 the roof is carried on a brick wall 40 the end of the rafters 13 being connected to a channel section member 41 by means of angle brackets connected between the central part 19 of the web of the rafter 13 and the flanges 42 of the member 41. The member 41 is provided with end flanges 43 which are bolted to the wall 40 as best shown in Figure 7.

If desired, the wall 40 may be located at a position inwardly of the end 16 of the rafters as shown in the left hand side of Figure 6 in which case the rafter 13 would be secured to one side of the member 41 by suitable angle brackets.

In a further embodiment of the invention described with reference to Figures 9 to 12 a building comprises a pitched roof 110 including a framework 111 which is clad with metal sheets 112. If desired translucent plastics panels may be incorporated in one or more of the sheets 112.

The framework 111 comprises a plurality of pairs of rafters 113. The rafters of each pair are co-planar and are connected together at their one end 114 as shown in Figure 11 and are supported at their other ends upon stanchions 115 which are made of conventional hot rolled I-section joints.

Each rafter 113 is in the form of a lattice girder as best shown in Figure 12 and comprises upper and lower booms 116*a* and 116*b* respectively, each boom 116*a*, 116*b* is of the shape and dimensions described hereinbefore with reference to and as shown in Figure 13 and the same reference numerals have been used in Figures 9 to 12 as were used in connection with Figure 13 to refer to corresponding parts.

Extending between adjacent flange portions 17 of the upper and lower booms are a plurality of lattice elements 121, 122 each of which is in the form of a circular cross section tube having a pair of flattened end portions 123. The lattice elements 121 122 are secured to the upper and lower booms by means of bolts 124.

At one end the lattice girder is provided with a pair of apex plates 125 secured by means of a lug 126 and bolts 127 to the flanges of the upper and lower booms whilst at the other end a pair of eaves plates 128 are secured by means of lugs 129 and bolts 130. It will be noted that the end lattice element indicated at 122*a* in the drawings is fixed to the lug 129, and by bolt 129*a*.

Three cleats 131 are fixed to the upper surface of the upper boom 116*a* for attachment of purlins 132 which are also made by cold rolled forming of sheet metal and are preferably of the configuration shown in Figure 13 or may be of the configuration shown in Figures 14 to 18. The purlines 132 are connected to the rafters 113 by bolting together the web 18 and the cleats 131. Diagonal cross bracing 133 is provided between adjacent rafters and stanchions.

Metal sheets 112 are secured to the purlins 132 in conventional manner. The rafters are secured by bolts passing through openings 134, to the stanchions 115 and the apex plates are secured together by bolts, not shown, passing through openings 135. The cross bracing 133 is connected by bolts passing through openings 136*a* to an apex cleat 136 bolted to the apex end plates 125.

The stanchions 115 carry an eaves beam 137 bolted to the stanchion via a cleat 138. The stanchions also carry sheeting rails 139 bolted to the stanchion via cleats 140. The eaves beam and sheeting rails are again formed of cold rolled sheet material and are preferably of the configuration shown in Figure 13 but may be of the configuration shown in Figures 14 to 18.

At the ends of the building are provided gable ends 141 of a construction shown in figure 9 and if the size of the building requires it gable posts 141*a* may be provided.

As in the case of the building described with reference to Figure 1 an alternative embodiment of the building may comprise a pitched roof of the same construction as described hereinbefore with reference to Figures 9 to 12 and instead of the roof being supported on stanchions the roof may be carried on a brick wall 40 as described with reference to Figures 6 and 7.

The rafters 113 may have parameters lying within the following ranges:

I XX	14352	-	68667	cm^4
Z X	638	-	1308	cm
R XX	40	-	50	cm
I YY	186	-	2532	cm^4
Z Y	32	-	200	cm
R YY	4.5	-	10	cm
Weight per metre	10	-	30	Kg.

When I = Moment of Inertia
Z = Section Modulus
R = Radius of Gyration

Because the rafters have the above properties they are relatively strong in relation to their weight, particularly as compared with conventional hot rolled rafters. In addition, because the lattice elements extend between both pairs of adjacent flanges the rafters have relatively high torsional rigidity thereby avoiding the need for any intermediate bracing.

Because the buildings described hereinbefore are produced from members made by cold rolled forming from sheet material the elements from which the building is constructed are light in weight, cold rolled material typically having a thickness of ⅛" or less. In buildings constructed from elements made by hot rolling the elements typically have a thickness in excess of ¼" and hence the elements are considerably heavier, more expensive and more difficult to handle than the elements of the building according to the present invention.

Although the elements of a building according to the present invention are relatively thin because they are of the sections described hereinbefore they have sufficient strength to

withstand the forces imposed thereupon in use and also are of such configuration as to facilitate connecting together of the various elements.

WHAT WE CLAIM IS:-

1. A lightweight building including a pitched roof comprising a framework covered by cladding, the framework comprising a plurality of pairs of rafters, the rafters of each pair being connected together at one end, co-planar and mutually inclined, the pairs of rafters being arranged in side by side relationship with purlins extending between adjacent pairs wherein each rafter comprises at least one cold rolled section comprising a pair of spaced parallel flange portions and a web extending between said flange portions the web comprising a planar central part which extends normal to the flange portions and is flanked by at least one inclined part so that the plane of the central part intersects at least one flange portion.

2. A building according to Claim 1 wherein the other ends of each rafter are inter-connected by a tension element.

3. A building according to Claim 1 or Claim 2 wherein each rafter comprises a single cold rolled section.

4. A building according to Claim 1 wherein each rafter comprises a lattice girder comprising cold rolled upper and lower booms inter-connected by lattice elements.

5. A building according to Claim 4 wherein the upper and lower booms each comprise a pair of spaced parallel flange portions and a web extending between said flange portions and there being lattice elements extending between adjacent flanges of the upper and lower booms.

6. A building according to Claim 4 or Claim 5 wherein the lattice elements comprise tubes, preferably of circular cross section, with flattened end portions.

7. A building according to any one of Claims 4 to 6 wherein the upper and lower booms and lattice elements are connected together by fastener elements.

8. A building according to any one of the Claims 4 to 7 wherein the upper and lower booms and lattice elements are removably connected together.

9. A building according to Claim 8 wherein the upper and lowr booms and lattice elements are removably connected together by means of screw threaded fasteners.

10. A building according to any one of Claims 4 to 9 wherein the lattice girder has, about a first axis, a moment of inertia lying in the range 14,352 to 68,667 cm^4; a section modulus lying in the range 638 - 1308 cm^3; a radius of gyration lying in the range 40 - 50 cm; and, about a second axis, a moment of inertia lying in the range 186 - 2532 cm^4; a section modulus lying in the range 32 - 200 cm^3; a radius of gyration lying in the range 4.5 - 10 cm; and having a weight per metre lying in the range 10 - 30 kg.

11. A building according to any one of the preceding claims wherein a rafter is supported at its said other end by a stanchion comprising a cold rolled section.

12. A building according to Claim 11 wherein each stanchion comprises a pair of spaced interconnected stanchion elements, one element being connected to a rafter at or adjacent said other end of the rafter and the other stanchion element being connected to the rafter at a position spaced inwardly of the position of connection of the first stanchion element.

13. A building according to Claim 12 wherein the stanchion elements converge downwardly and are mounted on a common foundation engaging base.

14. A building according to Claim 13 wherein said one stanchion element is vertical and the other stanchion element is co-planar therewith and inclined thereto.

15. A building according to any one of the Claims 1 to 11 wherein a rafter is supported at said other end by a stanchion comprising a hot rolled section.

16. A building according to Claim 15 wherein said stanchion is of I-section.

17. A building according to any one of the preceding claims wherein a stanchion is provided at said one end of each rafter and the stanchions are inter-connected by a cold rolled eaves rail at or adjacent their upper ends and by cold rolled side rails and the cladding being supported on cold rolled purlins of the roof and the eaves rail and the side rails of the stanchions.

18. A building according to Claim 17 wherein the rafters stanchions, purlins, eaves rails and side rails are releasably connected together by fastener elements.

19. A building according to any one of the preceding Claims wherein the or each flange portion of the cold rolled section is of generally L-shape in cross-section, one leg of the L being shorter than the other and constituting a lip on said one flange portion.

20. A building according to Claim 19 wherein the lip extends outwardly on the opposite side of the flange portion to the central part.

21. A building according to Claim 19 wherein the lip extends inwardly on the same side of the flange portion to the central part.

22. A building according to Claim 20 or Claim 21 wherein the lip extends normal to its flange part.

23. A building according to Claim 20 or Claim 21 wherein the lip extends in a direction inclined to its flange part in a direction towards the central part.

24. A building according to Claim 20 or Claim 21 wherein the lip extends in a direction inclined to the flange part away from the central part.

25. A building according to any one of the preceding Claims wherein the inclined part of the cold rolled section extends on the opposite side of the central part to the free end of the flange.

26. A building according to any one of Claims 1 to 25 wherein the central part of the cold rolled section is flanked by two inclined parts and said inclined parts extend on the same side as the central part and diverge away from each other.

27. A building according to any one of Claims 1 to 25 wherein the central part of the cold rolled section is flanked by two inclined parts and said inclined parts extend on opposite sides of the central part and lie generally parallel.

28. A building according to any one of the preceding Claims wherein the inclined parts extend directly from the flange portion.

29. A building according to any one of Claims 1 to 27 to 28 wherein the inclined parts are connected to their associated flange portion by an end part which lies parallel to said central part.

30. A building according to any one of the preceding claims wherein at least one of the cold rolled sections has about a first axis, a moment of inertia lying in the range 93 - 1266 cm^4; a section modulus lying in the range 16 - 100 cm^3; a radius of gyration lying in the range 4.5 - 9.7 cm and, about a second axis, a moment of inertia lying in the range 24 - 47 cm^4; a first section modulus lying in the range 5.6 - 10.5 cm^3 a second section modulus lying in the range 7.9 to 15.3 cm^3; a radius of gyration lying in the range 2.3 to 1.8 cm and a weight per metre lying in the range 3.5 - 10.8 Kg.

31. A building substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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1562688 COMPLETE SPECIFICATION
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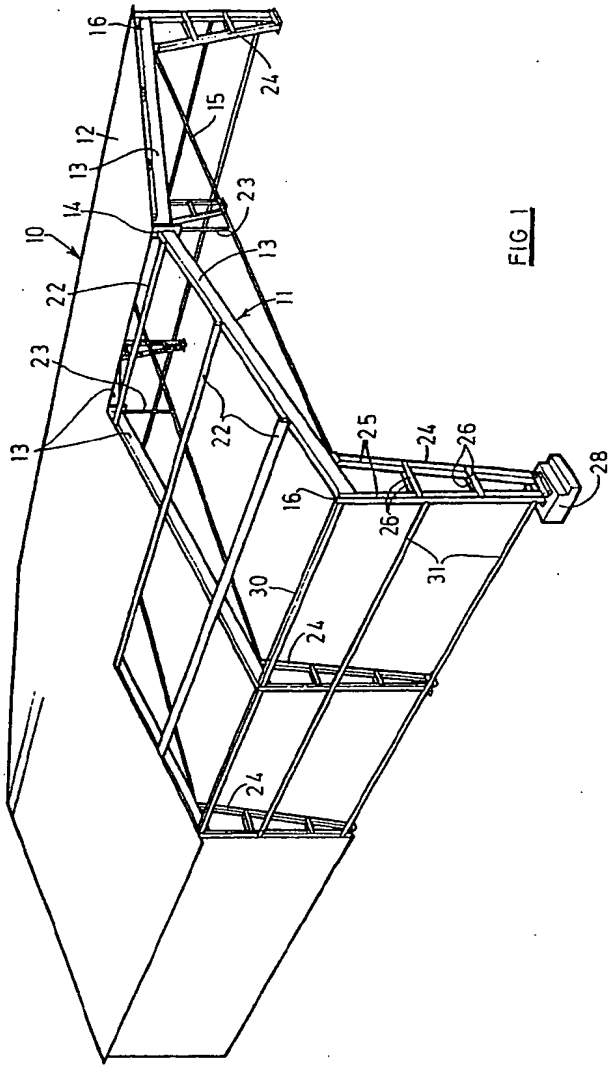

FIG 1

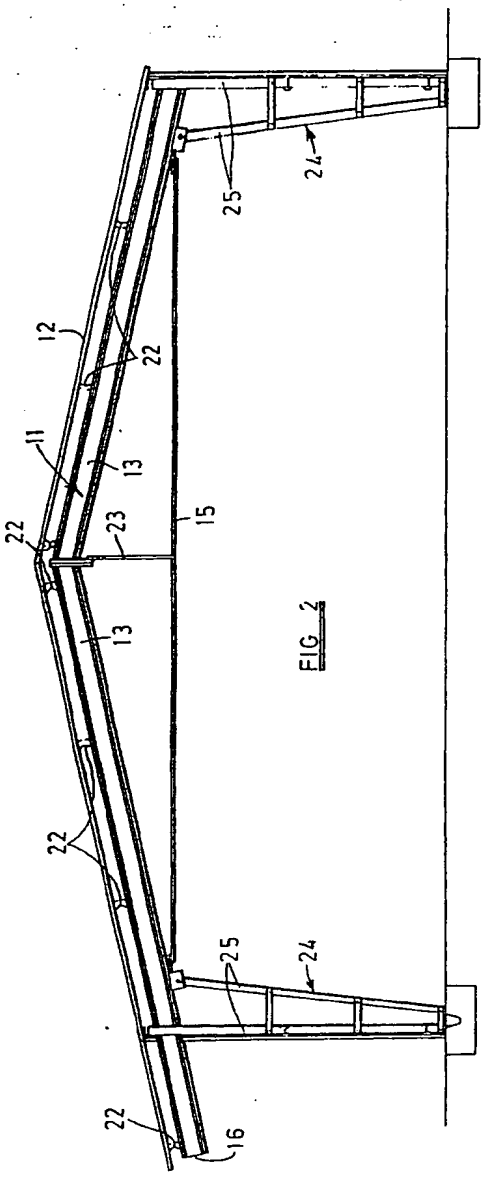

FIG 2

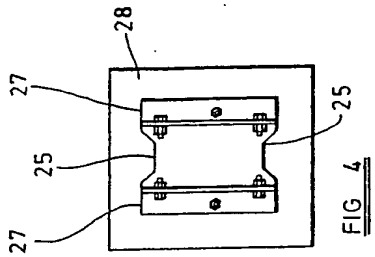

FIG 4

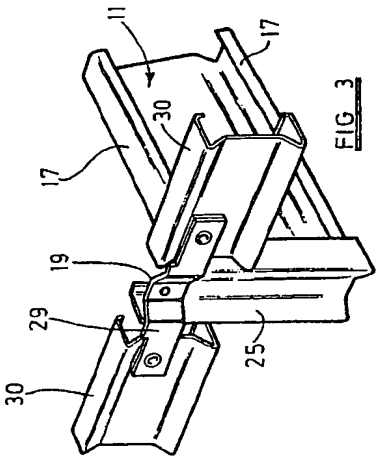

FIG 3

1562688 COMPLETE SPECIFICATION

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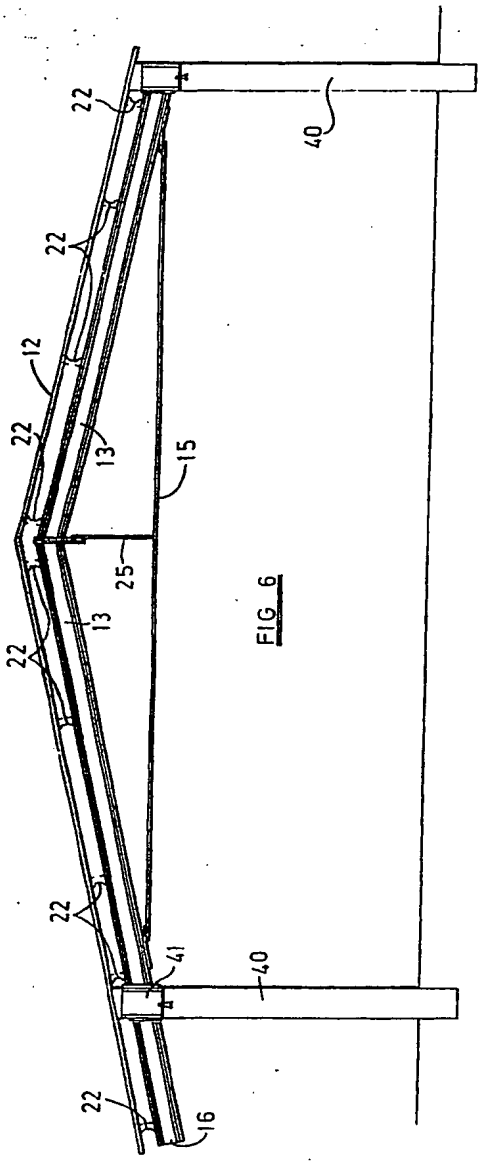

FIG 6

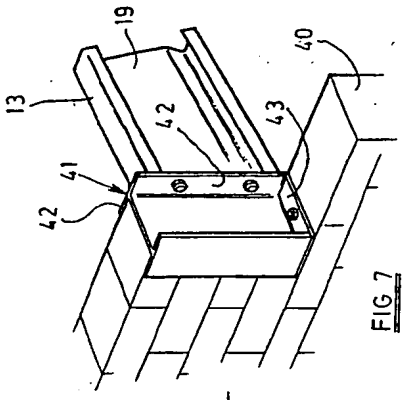

FIG 7

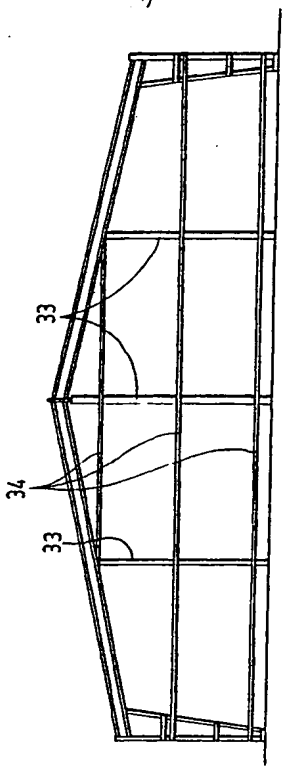

FIG 5

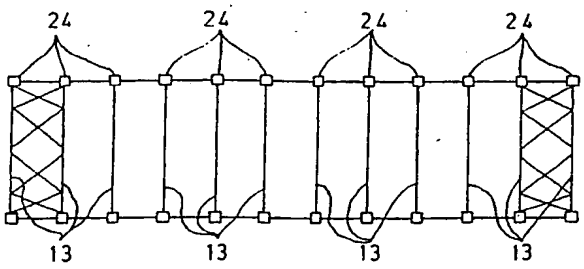

FIG 8

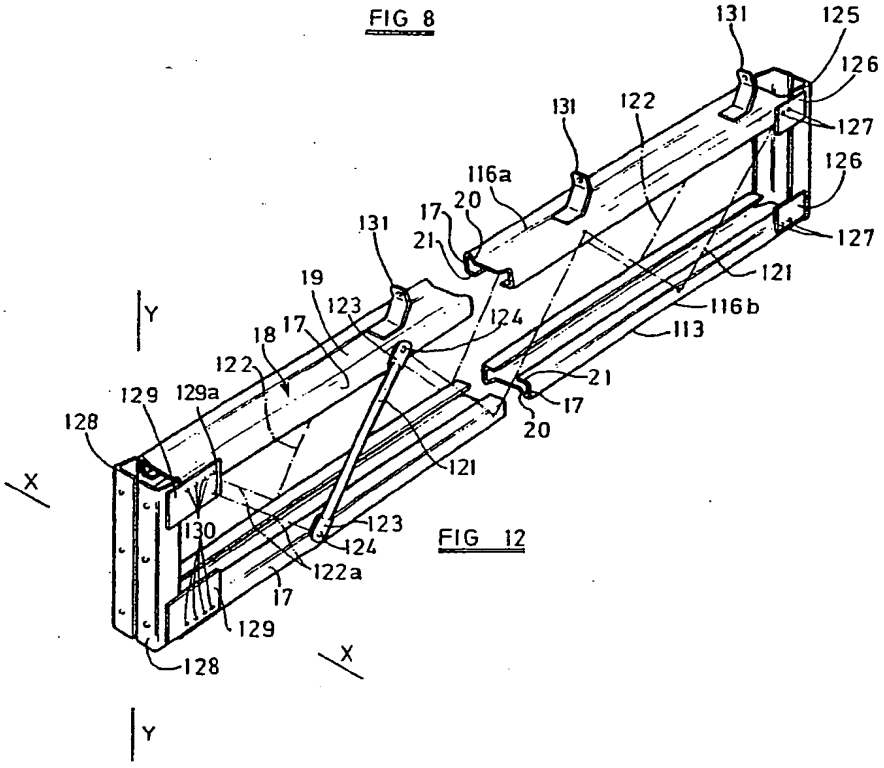

FIG 12

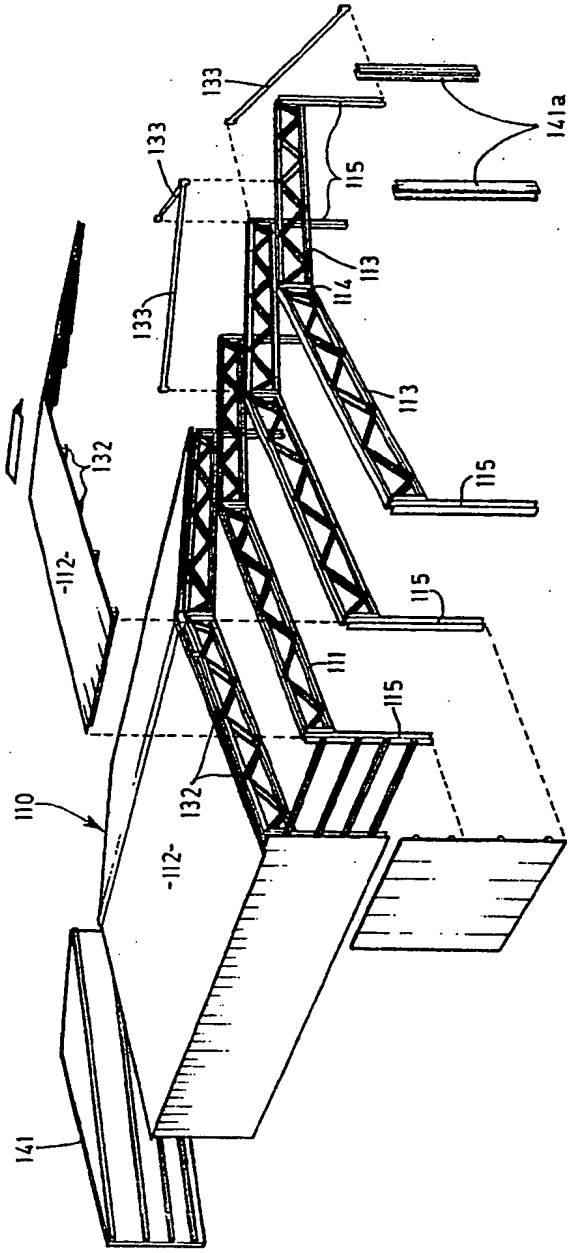

FIG 9

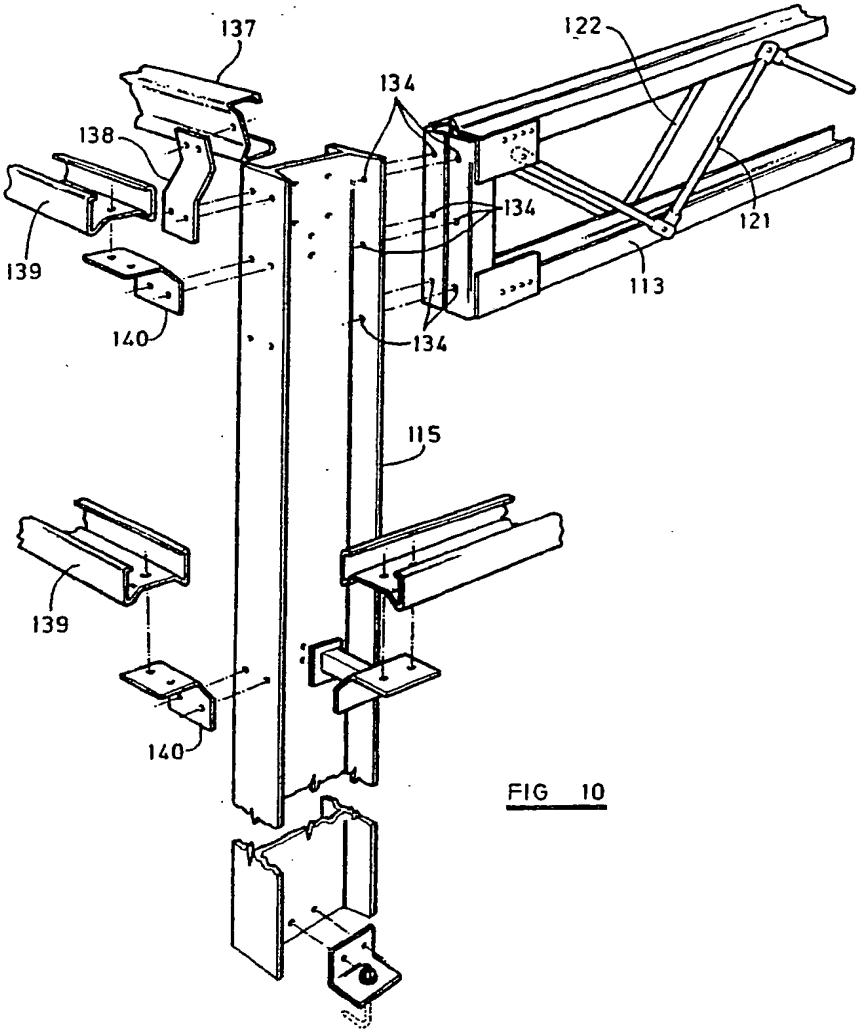

FIG 10

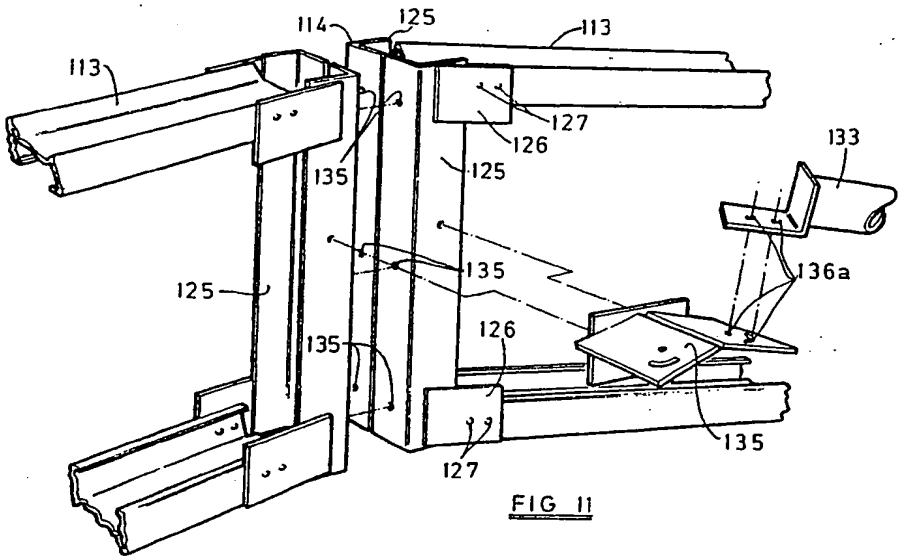

FIG 11

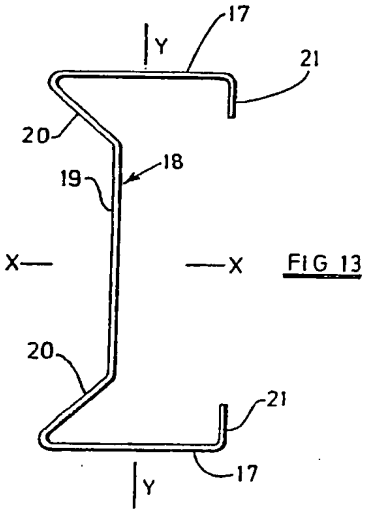

FIG 13

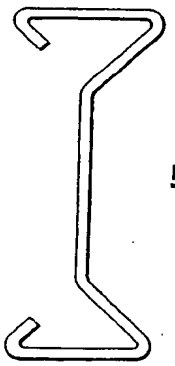

FIG 14

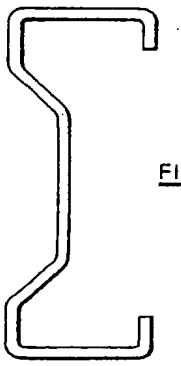

FIG 15

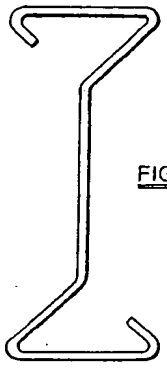

FIG 16

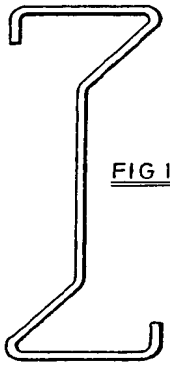

FIG 17

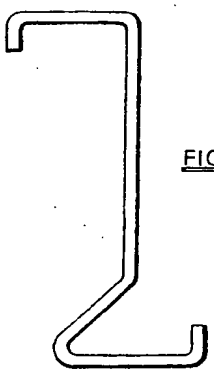

FIG 18